US008951773B2

(12) **United States Patent**
Kato et al.

(10) **Patent No.: US 8,951,773 B2**
(45) **Date of Patent: Feb. 10, 2015**

(54) **PRODUCTION METHOD FOR BIOFUEL**

(75) Inventors: **Hiroaki Kato**, Nagareyama (JP); **Ko Yamashita**, Kawaguchi (JP); **Yukio Fukushima**, Matsudo (JP); **Ken Amano**, Hitachiota (JP); **Takashi Kaneko**, Tokyo (JP); **Iwao Ueda**, Tokyo (JP); **Nobuo Aoki**, Tokyo (JP); **Kengo Suzuki**, Tokyo (JP); **Ryo Arashida**, Tokyo (JP); **Ryohei Nakano**, Tokyo (JP)

(73) Assignees: **Hitachi, Ltd.**, Tokyo (JP); **JX Nippon Oil & Energy Corporation**, Tokyo (JP); **euglena Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/699,780**

(22) PCT Filed: **May 25, 2011**

(86) PCT No.: **PCT/JP2011/061998**

§ 371 (c)(1),
(2), (4) Date: **Nov. 26, 2012**

(87) PCT Pub. No.: **WO2011/148981**

PCT Pub. Date: **Dec. 1, 2011**

(65) **Prior Publication Data**

US 2013/0071889 A1 Mar. 21, 2013

(30) **Foreign Application Priority Data**

May 26, 2010 (JP) 2010-121042

(51) **Int. Cl.**
C12N 1/00 (2006.01)
C12N 1/12 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***C12P 7/64*** (2013.01); ***C12P 7/6463*** (2013.01); ***C12P 7/649*** (2013.01); ***C10L 1/02*** (2013.01); *C10G 2300/4043* (2013.01); *Y02E 50/13* (2013.01); *C10G 2300/1014* (2013.01)
USPC **435/243**; 435/257.4; 435/257.1

(58) **Field of Classification Search**
USPC 435/243, 257.4, 252.1, 257.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0160591 A1 7/2008 Willson et al.

FOREIGN PATENT DOCUMENTS

JP 59-118090 7/1984
JP 61-254193 11/1986
(Continued)

OTHER PUBLICATIONS

Mata et al., Microalgae for biodiesel production and other applications: A review. Renewable and Sustainable Energy Reviews, vol. 14 (online Aug. 3, 2009) pp. 217-232.*
(Continued)

Primary Examiner — Jon P Weber
Assistant Examiner — Kara Johnson
(74) *Attorney, Agent, or Firm* — Antonelli, Terry, Stout & Kraus, LLP.

(57) **ABSTRACT**

The present invention provides a production method for biofuel based on a technology to convert carbon-dioxide as a carbon source through photosynthesis by photosynthetic microorganisms to biomass and produce biofuel of the biomass. The production method for biofuel of the present invention comprises a culturing process (S**1**) of culturing in a culture solution photosynthetic microorganisms which store oils, fats and carbohydrates in cells of the photosynthetic microorganisms, an oil and fat conversion process (S**2**) of converting the carbohydrates stored in the cells of the photosynthetic microorganisms cultured in the culture apparatus to oils and fats, an extraction process (S**3**) of extracting the oils and fats out of the cells of the photosynthetic microorganisms, and a reforming process (S**4**) to reform the extracted oils and fats.

20 Claims, 2 Drawing Sheets